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THE SELECTION, INSTALLATION, AND AIRBORNE TESTING OF AN AIRCRAFT TEMPERATURE AND HUMIDITY SENSOR SYSTEM

(NASA-TM-X-74651) THE SELECTION, INSTALLATION, AND AIRBORNE TESTING OF AN AIRCRAFT TEMPERATURE AND HUMIDITY SENSOR SYSTEM (NASA) 32 p

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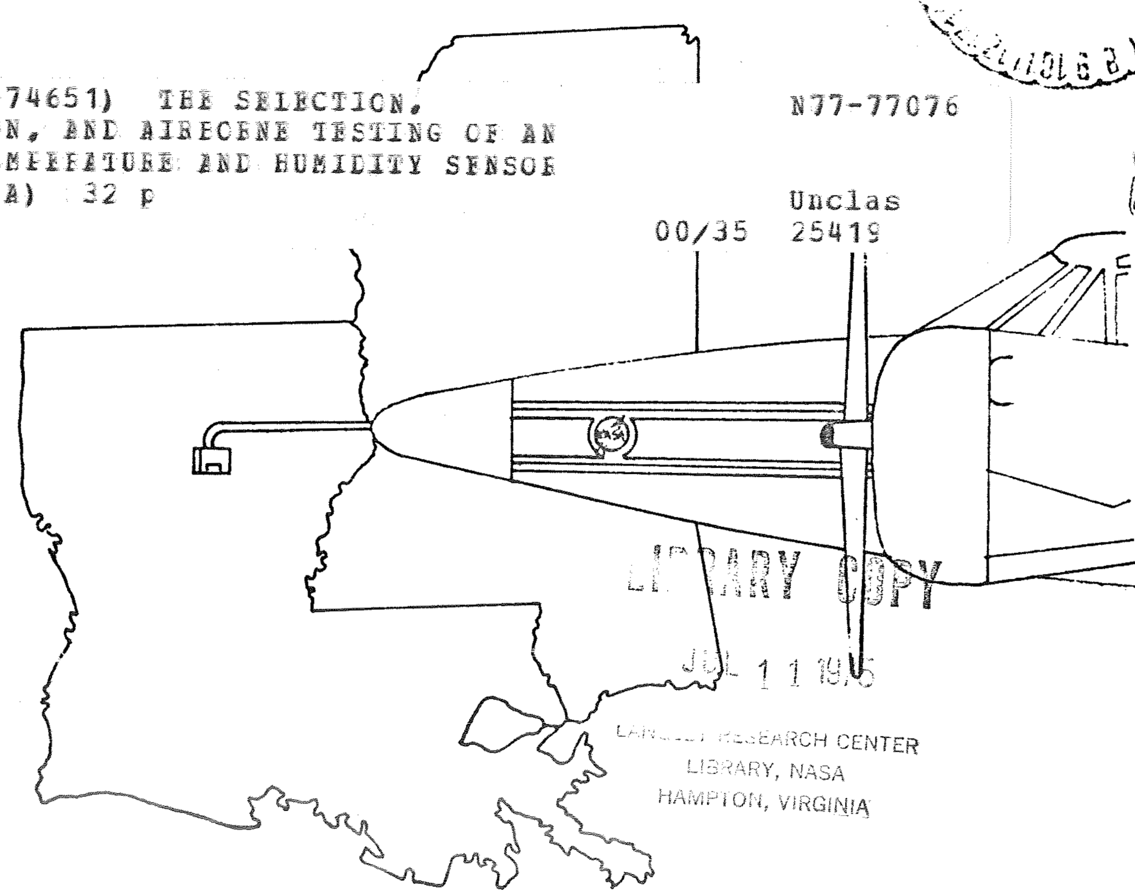

REPORT NO. 136

FEBRUARY 1975

LYNDON B. JOHNSON SPACE CENTER

THE SELECTION, INSTALLATION, AND AIRBORNE TESTING OF AN AIRCRAFT TEMPERATURE AND HUMIDITY SENSOR SYSTEM

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February 5, 1975

ERL Report No. 136

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THE SELECTION, INSTALLATION, AND AIRBORNE TESTING
OF AN AIRCRAFT TEMPERATURE AND HUMIDITY SENSOR SYSTEM

I. ABSTRACT/SUMMARY

This report describes the evaluation of a new type of airborne temperature and humidity sensor. This sensor, which utilizes a new method to detect moisture at a molecular level, has a 300 millisecond response and typical accuracy of $\pm 2\%$ RH. The temperature is measured with a calibrated thermistor and has a typical accuracy of $\pm 0.3°C$.

The sensor installation on the aircraft is discussed and a practical evaluation test is reviewed. In addition to the details of this sensor testing, other types of aircraft temperature and humidity sensors are discussed.

The testing indicates that the blade/sensor is not speed dependent in either the humidity or temperature parameter when the blade is mounted on a probe at the forward portion of the aircraft; however, when the blade is mounted beneath the aircraft, against the aircraft surface, some speed dependency is detected in the humidity measurement.

II. BACKGROUND

The Earth Resources Laboratory (ERL) has a requirement to make temperature and humidity measurements from an aircraft to support its remote sensing programs. An evaluation study was effected, the objectives which were to:

1. Review the methods of measuring temperature and humidity from aircraft.
2. Select the sensor system best suited to ERL's programs.
3. Evaluate the sensor in a laboratory.
4. Evaluate the sensor on an aircraft.

A. General Methods for Making Airborne Air Temperature and Humidity Measurements

1. Sensor Housings

Measuring the true air temperature or humidity outside of an aircraft requires a device to shield the sensor from the direct airstream, while avoiding stagnated air or areas of turbulence caused by the aircraft. This aerodynamic problem is minimized by the selection and proper mounting of a well-designed sensor housing. One type of sensor housing is an aerodynamically designed blade or probe. The properly designed blade systems should simulate a nonmoving air environment, but in reality they are velocity dependent, some more so than others.

Some detector systems require an external airscoop to duct the ambient outside air into a measurement chamber inside the aircraft. This is rarely the first choice of systems for just a temperature or humidity measurement because of the cooling or heating effects of the apparatus on the air parameters to be measured.

2. Temperature Sensors

The generally accepted aircraft temperature sensor is a platinum resistance wire mounted in a probe. The stability and repeatability of platinum wire probes when used in a bridge circuit are very accurate and reliable.

Thermistors are also used in probe systems but the expense of a complete temperature system; i.e., aircraft probe, signal conditioning electronics, operator control panel, aircraft wiring and modifications, etc., usually justified the more expensive platinum element. While platinum resistance calibrations are standardized in temperature vs. resistance, each thermistor must be laboratory calibrated.

3. Humidity Sensors

There are a number of instruments used to specify atmospheric moisture, the four most popular are:

a. Wet/dry bulb temperature indicators
b. Dew point indicators
c. Relative humidity hygristors
d. Water molecule detectors

a. Wet/dry bulb (psychrometry) is the best known and simplest measuring method involving a dry air temperature sensor and another similar sensor, but in a wetted condition. This wet/dry temperature measurement can yield relative humidity or dew point, but it has the disadvantage of requiring a constantly, evenly wetted detector in an aircraft. This necessitates water reservoirs, wicks, and a controlled air flow across the wet and dry sensors. These devices are very slow in response and are better used for laboratory chamber monitoring or stationary atmospheric measurements where a nominal one-minute system response would be acceptable.

b. A dew point indicator is a device which measures the temperature to which a gas must be cooled at constant pressure to produce saturation. Dew point temperatures can be converted to vapor pressure units or water vapor content in parts-permillion. Most dew point systems detect light reflected from a mirrored surface. When the mirrored surface is electronically cooled and moisture develops on the surface, the detected, reflected light decreases. Heating the mirror evaporates the moisture so the mirror is clean (dry) for another measurement. A signal proportional to the detected light is used to regulate the temperature of the mirror so the cycle may be repeated. The mirror temperature is monitored and provides the dew point measurements. Electronics regulate the lamp and detector currents, as variations in these would affect the apparent dew point temperature. This system's relatively slow response hinders the sharp definition of humid geographical areas often needed for coastal studies. The air flow over the mirrored surface must be extracted from the outside air and ducted to the instrument without influencing the air's temperature or pressure. The mirror surface should be clean at all times, or allowances must be made in the instrument. Even with these apparent drawbacks, the dew point indicator has been a popular airborne sensor system.

c. The relative humidity hygristor is another humidity system that has been widely used. These probes are sometimes mounted in external blades and operate well providing the blades are not very velocity dependent and receive and conduct no solar heating to the probe. The sensor must be protected from the salt air conditions experienced when flown low over salt water or operated from coastal airports when there is high saline dew.

These sensors have response times of a few seconds and require occasional probe cleaning or replacement and recalibration.

d. Water Molecule Detectors - A new type of humidity sensor, which detects moisture at a molecular level, has been recently developed. This design overcomes most of the defects or limitations of the other systems. Because the response is fast, the quoted accuracy acceptable, the cost reasonable, and the detector's operation not altered by salt environments, this molecular detection system[1] was chosen by the ERL for tests and evaluation and to be incorporated into an operational aircraft system.

III. SYSTEM DESCRIPTION

A. Sensor Physics

The operation of this sensor does not require that there be actual droplets of moisture formed on a surface or in a material. This detector relies on the presence of water molecules within the detector's structure. The sensing element, called a Brady Array, is 0.25 mm (0.009 in.) in diameter and 2.54 mm (0.01 in.) long and forms an array of crystals and internal voids. Water molecules can move freely through the array structure. The detection process of the sensor requires that the array be externally excited to vibrate at a frequency which is a sub-multiple of that of the water molecule.

[1]This system is manufactured by the Thunder Scientific Corporation, Albuquerque, N. M.

As water molecules intercept and penetrate the internal voids of the excited array, the structure begins to conduct. When the ambient moisture content decreases, the array reacts immediately causing the water molecules already present in the structure to be forced out of the structure resulting in a very low detection response time.

B. Specifications

This detector, which is mounted in a vented TO-5 transistor case in an aircraft blade system, has a response of 300 millisecond and a manufacturer's quoted accuracy of ±2% RH (see Table 1 Appendix). This rapid response is possible because the sensor relies on the molecular level of detection and does not require that actual condensation be present. In addition, since it does not require droplets or vapors to form at the detector, the recovery time does not involve an evaporation period.

A thermistor was selected by the manufacturer as the temperature sensor for this system because it could be installed in the transistor case with the Brady Array and in this way the temperature and humidity sensor would share a common blade, wiring, and to some extent, common electronics. The quoted accuracy of the calibrated thermistor is ±.5°C. This accuracy was acceptable for ERL's programs and the convenience and cost saving factors of a combined temperature and humidity system were appreciated.

The complete system consists of the aircraft blade[2], temperature

[2]This blade was originally constructed of aluminum and plated with gold. After a year of flying from a clean asphalt airport, the blade became eroded and discolored. A new blade was made from stainless steel. The new blade was made slightly higher to get the sensor farther from the aircraft skin. Except for the height, material, and coating, the old and new blades are identical. Since reporting this problem to Thunder Scientific their blades are now fabricated from stainless steel.

and humidity detector, humidity excitation oscillator, and signal conditioning module (see Figures 1, 2, 3, and 4 Appendix). The signal conditioning electronics was incorporated into a central control panel to display humidity and temperature on a meter and provide scaling electronics for a 0 to 5 VDC output from the temperature and humidity channels. The relative humidity meter has three ranges; 0 to 10% RH, 0 to 50%, and 0 to 100% RH. The input power is 28 VDC.

IV. SYSTEM INSTALLATION

The blade has been installed on two different twin-engine Beech aircraft. On the first aircraft the blade was installed on the lower, forward part of the fuselage (see Figure 5 for location). To avoid irreversibly modifying this aircraft, a replaceable inspection door was used as the mounting surface. The more desirable mounting location and position was used on the second and present aircraft (see Figure 5). This configuration has the blade extended from the nose of the aircraft to insure that the blade is in free-moving non-turbulent air. When the detector is mounted in the boundary layer of the aircraft, the sensor will not be exposed to the desired aerodynamic conditions. The sensor blade was mounted with the sensor facing down and a protective boot was made for the sensor to protect it from normal condensation during ground time. The excitation oscillator was mounted inside the forward portion of the aircraft fuselage and the control panel with the signal conditioning electronics was mounted in an instrument rack at the flight engineer's station.

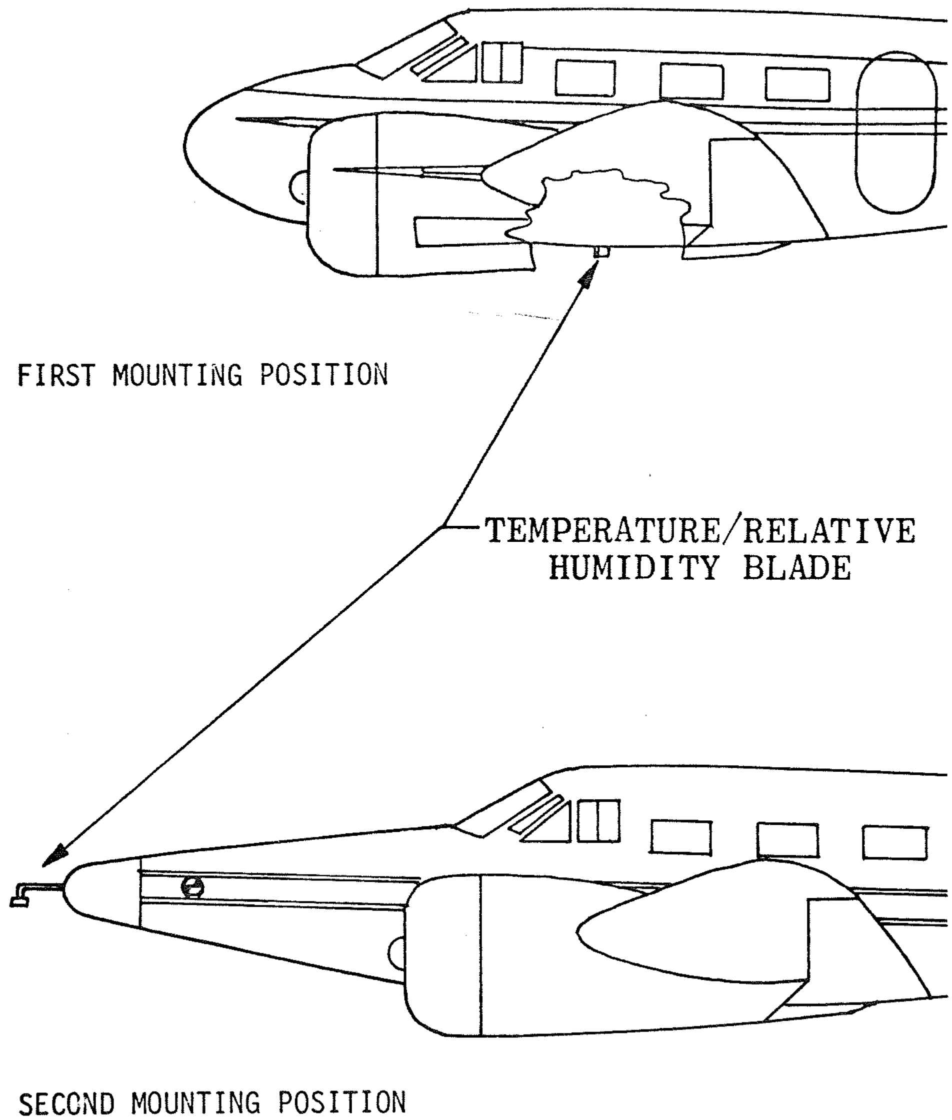

FIG. 5. AIRCRAFT BLADE MOUNTING LOCATIONS

V. SYSTEM CALIBRATION AND TESTING

A. Testing Philosophy

The testing and evaluation of this system were to consist of four parts:

Manufacturer's Laboratory Tests

Baseline Measurement at Local Laboratory

Speed Dependency Test

Altitude Dependency Test

B. Manufacturer's Laboratory Tests

The acceptance calibration and testing at the manufacturer's facility consisted of having the sensor installed in a temperature/humidity calibration chamber and monitored by a wet/dry psychrometer, both fabricated by the sensor manufacturer and certified by the National Bureau of Standards. The aircraft system was calibrated over the proper range of temperature and humidity and a family of curves were generated to relate voltage out vs. temperature and humidity. These curves generated by the manufacturer are used for all data reduction.

C. Baseline Measurement at Local Laboratory

The repeatability and long term stability should be determined locally even when an absolute calibration system is not available. This baseline measurement permits the user to have continued confidence in the manufacturer's data by determining the sensor stability. After the system was received at ERL, a local humidity and temperature chamber was used in an attempt to develop a repeatable temperature and humidity baseline. Because of the large size and non-homogeneities in the chamber volume, the chamber humidity curve was not repeatable, and the chamber was abandoned in favor of other methods.

The adopted method employed the use of saturated salts which, because of their basic physics, can be used for laboratory checks of humidity baselines. The ERL Instrument Laboratory used sodium carbonate, lithium chloride, and calcium chloride for the humidity references and a small oven, monitored with calibrated thermometers, for the temperature reference.

D. Speed Dependence of the Aircraft Blade as Tested on an Aircraft

It would be preferable to use a wind tunnel or chamber to dynamically calibrate an aircraft blade system, but very few wind tunnels can independently vary wind speed, temperature, and humidity; therefore, it was decided to test the system in an uncontrolled but monitored environment using standard radiosonde measurements as a reference. The speed dependency test on the first aircraft involved tethering a balloon borne radiosonde at an altitude of 107 meters (350 feet) and flying very near it at four different airspeeds; 58, 63, 67, and 72 m/s (130, 140, 150, and 160 mph). A comparison of the measurements would be made to determine if the blade was speed dependent and, if so, what correction factors were necessary. This testing was accomplished at a radiosonde facility utilizing standard receiving and data reduction equipment. The radiosonde was modified to minimize the effect of hygristor solar heating by shielding the hygristor duct cover from direct sunlight and providing a heat sink for the shield. It has been established by Morrissey and Brousaides (1970) and Ostapoff et al. (1970) that the hygristor required additional solar shielding to minimize the radiosonde humidity errors. The radiosonde had to be modified further to permit both temperature and humidity to be measured at a constant barometric pressure. A tethered radiosonde does not normally have the baroswitch switching between the humidity and temperature sensors as in the case of a rising radiosonde. A remotely controlled system was installed in the radiosonde so a ground operator could switch between these sensors and monitor either the air temperature or humidity at will.

Results of the test indicate that the temperature measured by the probe is not speed dependent but the humidity measurement is to some detectable amount (see Table 2). The findings were that the aircraft reads higher than the radiosonde by 1.5% RH at 58 m/s; 1.7% RH at 63 m/s; 2.0% RH at 67 m/s; and 2.4% RH at 72 m/s (130, 140, 150, and 160 mph). The constant temperature offset (T_a - T_r), as shown in ΔT column, is apparently due to radiosonde inaccuracies and is discussed in a subsequent paragraph.

The evaluation of the radiosonde and aircraft data, test parameters, reduction technique, etc., indicates that the blade is not speed dependent between 58 m/s and 72 m/s (130 and 160 mph) for the temperature measurement and less than 3% RH for the humidity measurement in aircraft configuration #1. Data was taken as the aircraft approached and departed the immediate vicinity of the radiosonde. This was necessary to insure that there were no large fluctuations in any of the data.

E. Altitude Dependency Tests

The purpose of the test was to expose the aircraft system to varying temperature and humidity environments over a range of altitudes. The test environment was monitored by a freely ascending balloon-borne radiosonde. The intent was not to use a radiosonde for absolute calibration of an aircraft temperature and humidity system, but to use the radiosonde for the additional information it provides in interpreting the aircraft system data.

TABLE 2 -- Aircraft Speed Dependency Test with Tethered Radiosonde

Temperature

Velocity m/s	Radiosonde T_r (C°)	Aircraft T_a (C°)	ΔT Ta-Tr (C°)
58	24.0	25.6	+1.6
63	24.2	25.9	+1.7
67	24.5	26.2	+1.7
72	24.7	26.2	+1.5

Humidity

Velocity m/s	Radiosonde R_r (%RH)	Aircraft R_a (%RH)	ΔR Ra-Rr (%RH)
58	44.5	46.0	+1.5
63	44.0	45.7	+1.7
67	43.5	45.5	+2.0
72	43.0	45.4	+2.4

A radiosonde was prepared for launch and ballasted so that the ascent rate would be slow enough that the aircraft could circle the balloon and still maintain a nominal airspeed used during routine remote sensing missions. Following a free flying radiosonde was the only way the probe could be exposed to a range of temperatures and humidities and have an acceptable external monitor[3]. The maximum altitude the aircraft flies on ERL missions is 3048 meters (10,000 ft.) so no balloon data were taken above this altitude. It was planned for the aircraft to follow a balloon to 3048 meters (10,000 ft.) altitude, return to an altitude of 61 meters (200 ft.) and immediately follow a second balloon for comparison. These tests were performed on a cloudless day. The first release had too little ballast and at an approximate altitude of 2438 meters (8000 ft.) the aircraft could not maintain the preferred speed and climb rate. This first balloon release was not used for analysis because of the 4 m/s (13 ft/sec) ascent rate. The second release was over-ballasted and the aircraft ran out of instrument recorder tape before the desired 3048 meters (10,000 ft.) altitude was reached. The third release was ballasted properly and the aircraft was able to perform the test within all the test parameters. The second release of 1.5 m/s (5 ft/sec) ascent and the third of 3.6 m/s (12 ft/sec) were used for data reduction and analysis.

[3]Several radiosondes were adjusted so that no two would be on exactly the same frequency, but still in the 1680 KH_z weather service band. This was necessary so that in case of a failure and the launch of another balloon, the aircraft could follow the second balloon without waiting for the first balloon to stop transmitting.

The temperature and humidity ordinate values from the free balloon radiosonde were reduced with a standard meteorological slide rule from strip chart records provided by the radiosonde facility personnel. A table for standard atmosphere was used to convert the radiosondes' barometric pressure readings to altitude. These altitude readings and the aircraft's altitude, humidity, and temperature measurements were plotted against the time they were recorded. The aircraft and radiosonde data were correlated so that a direct comparison could be made.

As the data reduction progressed, the perturbations in radiosonde data became a more significant factor. Basically, the radiosonde is "captured" by very small localized weather patterns which the aircraft may not fly through even while in comfortable viewing distance from the balloon. While this introduces differences, they are not necessarily errors. The necessary "corrections" to the non-tethered radiosonde data was determined to be useless for this aircraft sensor evaluation and was abandoned as test data.

F. Speed Dependence Test of the Aircraft Blade as Tested in a Second and More Preferred Position

1. Approach

The blade was installed on a probe at the forward end of the fuselage. A second speed dependence test was performed, but without the use of a radiosonde (see Figure 6).

This approach had the aircraft fly at an altitude of 9 meters (30 ft.) over a private airport runway at four speeds; 58, 62, 67, and 72 m/s (130, 140, 150 and 160 mph). There were

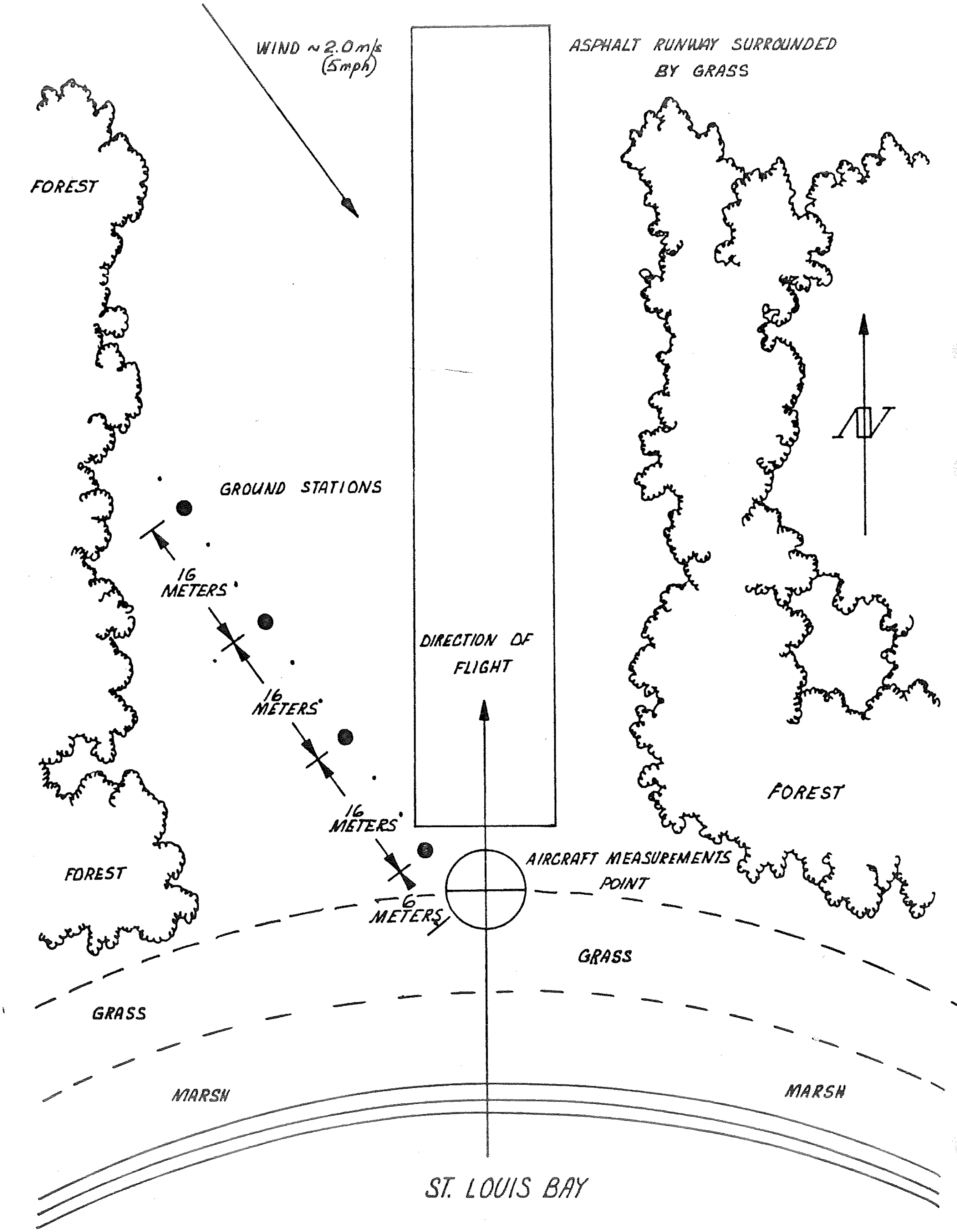

FIG 6. DATA ACQUISTION LAYOUT OF TEST AREA

four passes at each speed. Four ground teams made temperature and humidity measurements in close proximity and upwind of the aircraft flight line. The aircraft crew verbally marked the temperature and humidity data tape when the aircraft passed a predetermined landmark selected as the planned measurement point. Wind direction and strength were important factors as all of the ground teams were placed in a line upwind of the measurement point. The distance the ground teams were placed from the aircraft measurement point was an on-the-field decision and depended on the wind velocity. These teams were positioned upwind because the ground level air masses would be rising in a slanted line downwind and at some angle, depending on wind velocity and terrain. If there were very little wind, the aircraft would fly through an air mass whose source of temperature was very close to the aircraft measurement point. Consequently, the ground measurement teams would be closer together and close to the aircraft measurement point. If the wind speed were higher, the teams would be separated more, as the measurement point air mass temperature source would be at a smaller angle to the ground. Of course, if the wind were very gusty, the ground and near-ground air mass would become very homogeneous and less faith could be placed in any decision to position the ground measurement crews upwind.

The ground crew used sling psychrometers and psychrons. A series of tests were performed to determine the repeatability of these instruments prior to the speed dependency tests. The repeatability of the sling psychrometer was within $\pm 1.1\%$ RH error while the psychron repeatability was within $\pm 0\%$ RH. The sling psychrometer suspended in front of a fan yielded $\pm 0\%$ RH repeatability. So, while the personnel using these instruments were familiar with the instruments' operation (having used them on numerous other ERL ground truth exercises), the $\pm 1.1\%$ RH variations in the sling psychrometer readings can be attributed to individual technique rather than instrumentation.

2. Data Acquisition

The speed dependency test was performed on December 9, 1974 at 1:00 p.m. The aircraft made long approaches over St. Louis Bay to be assured of reaching the measurement point at the proper altitude, direction, and speed. The ground crew repeatedly made measurements of temperature and humidity but recorded only those corresponding to the time the aircraft passed the measurement point. This permitted the ground crew to monitor the consistency of their measurements and repeat any measurement that indicated a very short term, radical change in temperature or humidity.

3. Data Reduction

The analog magnetic tape from the aircraft was reduced to tabular form and the time listed on the tabular outputs was referenced to the time the aircraft was over the measurement point.

4. Test Results

Analysis of the data at each aircraft speed indicates that the sensor and probe, when mounted in the preferred location, is not speed dependent (Table 3). The average of the temperature measurements from the ground ($T_{G\ ave}$) is subtracted from the average aircraft temperature measurement ($T_{A\ ave}$) to get a difference. This was done for each aircraft speed. The temperature differences measured are within the range of the sensors' accuracies.

In the case of the humidity measurements, the same approach was taken to determine the differences in ground and aircraft measurements. Again it is seen that the measurement by the nose probe is not speed dependent. If the humidity difference at an aircraft speed of 58 m/s (130 mph) had been more negative than -.94, a trend would have been detected since the differences from 62 m/s (140 mph) to 72 m/s (160 mph) are all becoming more positive. The individual humidity measurements which make up the 58 m/s (130 mph) average were reviewed to confirm that these measurements were correct and that the measurements were not affected by speed variations.

In summary, the data indicate that this aircraft blade system is not speed dependent in temperature and humidity between the aircraft speeds of 58 and 72 m/s (130 and 160 mph) when mounted on a probe on the forward nose portion of the aircraft.

5. Test Measurements Error Analysis

The aircraft sensor outputs were analog recorded on magnetic tape and digitized at 10 samples per second within 0.8% accuracy. The variations between 10 samples with constant inputs were no more than 20 MVDC on either parameter, and this 20 MVDC variation corresponds to only .75% RH and .28°C. The aircraft recording

TABLE 3 -- Aircraft Speed Dependency Test Over Ground Stations

Temperature

Speed M/S	T_G Ave (C°)	T_A Ave (C°)	ΔT $T_A - T_G$ (C°)
58	11.04	11.01	- .04
62	10.86	10.35	- .51
67	11.21	10.56	- .65
72	11.13	10.97	- .16

Relative Humidity

Speed M/S	R_G Ave (%RH)	R_A Ave (%RH)	ΔR $R_A - R_G$ (%RH)
58	40.50	40.38	- .12
62	40.94	40.00	- .94
67	38.56	38.63	+ .07
72	36.81	38.38	+1.57

system contributed -10 MVDC to +20 MVDC variations to the overall aircraft recording system. This demonstrates the amount of variation from the internal sensor electronics and the aircraft data system. Of the ground measurement devices, the psychron has ±0.0% RH repeatability error and the psychrometers have ±1.1% RH repeatability error; therefore, the major source of error again is the ground measurement system - first the radiosonde hygristors and then the psychrometers.

VI. CONCLUDING REMARKS

The development of confidence in an airborne system starts with the appraisal of the sensor's static calibration accuracy, then the system electronic's stability, and last, the conversion of electrical units to engineering units. The static calibration and speed dependency tests provide the greatest source of confidence in an aircraft system.

Laboratory calibration of the temperature and humidity system is possible and field speed dependency testing is practical.

As shown in this exercise, the repeatability, the apparent lack of speed-dependent trends, and the demonstrated ruggedness of the temperature and relative humidity system indicate that this system, properly mounted in an aircraft and operating with a stable recording system, will easily perform to the manufacturer's specifications and meets a nominal remote sensing aircraft program needs.

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VII. APPENDIX.

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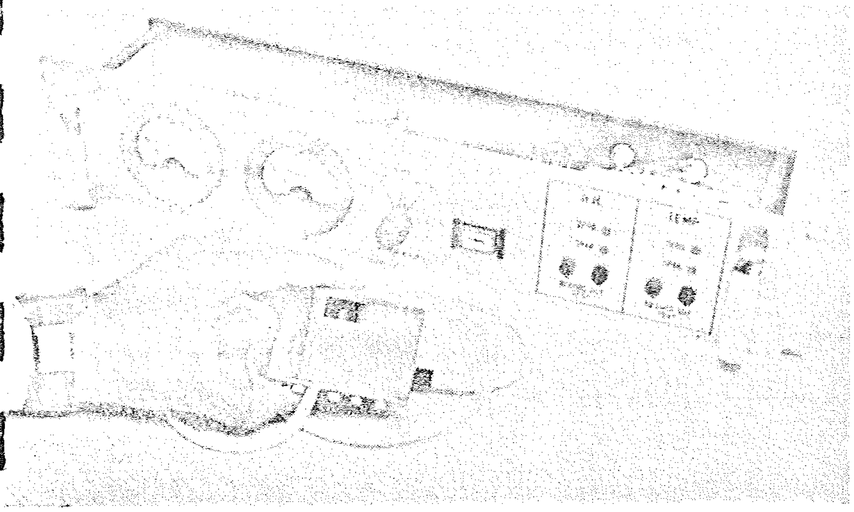
TABLE 1 -- Manufacturer's Specification

THUNDER SCIENTIFIC

DEVELOPMENTAL SPECIFICATION

AIRCRAFT BLADE-MOUNTED HUMIDITY AND TEMPERATURE MEASUREMENT SYSTEM

MODEL E-102-1



The E-102-1 Aircraft Blade System provides the capability to monitor, readout and record humidity and temperature on aircraft of different types while flying at various altitudes. The system responds rapidly, for tracking fluctuating levels of relative humidity while flying at speeds of up to 350 knots.

The system provides a visual analog readout 0-5 VDC calibrated for 0% RH to 100% RH and 0 to 122°F on front panel meters within a 19" x 3½" rack panel. In addition, two 0-5 VDC, 70 ohm outputs are available at the rear of the chassis for direct or magnetic tape recording. Additional test jacks are available on the front panel.

SPECIFICATIONS - MODEL E-102-1

Relative Humidity

Sensor Type:	Brady Array Model BR-101R.
Mounting:	Blade configuration for wing and/or fuselage mounting.
RH Range:	0% RH to 100% RH.
Guaranteed Accuracy:	Better than ±2% indicated RH.
Temperature Range:	-20°C to +70°C (broader ranges available at slight additional cost).
Output:	0-5 VDC, calibrated for 0% RH to 100% RH.
Power:	Standard 15 VDC at 5 ma (other voltages available upon request).

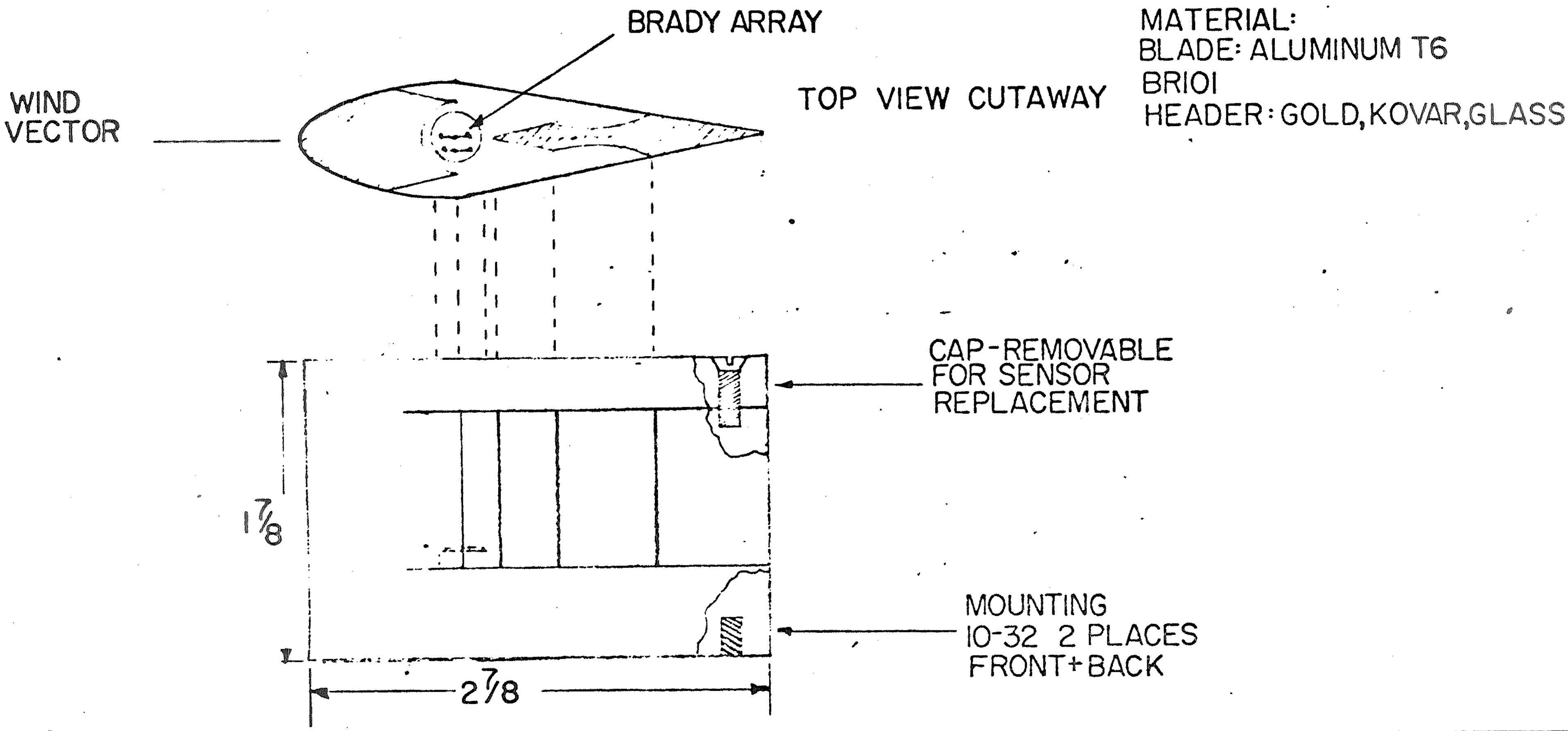
Temperature

Sensor:	Thermistor bead.
Mounting:	Within Brady Array enclosure.
Range:	-20°C to +70°C (broader ranges available at slight additional cost).
Guaranteed Accuracy:	±1°F standard (special calibration available at additional cost).

Typical Calibrated

Accuracy:	Better than ±0.1°F.
Output:	0-5 VDC calibrated to temperature into 70 ohm resistive load.

623 WYOMING, S.E. ☐ ALBUQUERQUE, NEW MEXICO 87123 ☐ TEL. (505) 265-8701



THUNDER SCIENTIFIC CORP.		
SCALE: 1:1 DATE: 2/2/72	APPROVED BY	DRAWN BY JB
BLADE: FUSELAGE, WING, AND, OR POD MOUNTING.		
BRADY ARRAY, HUMITY SENSOR		DRAWING NUMBER E 102

FIGURE 1

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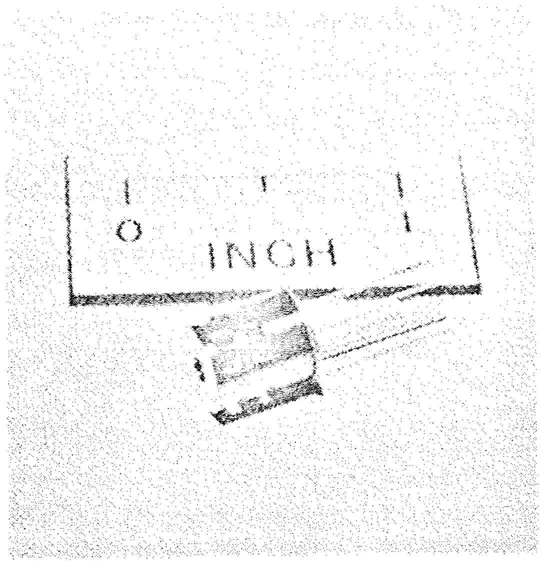
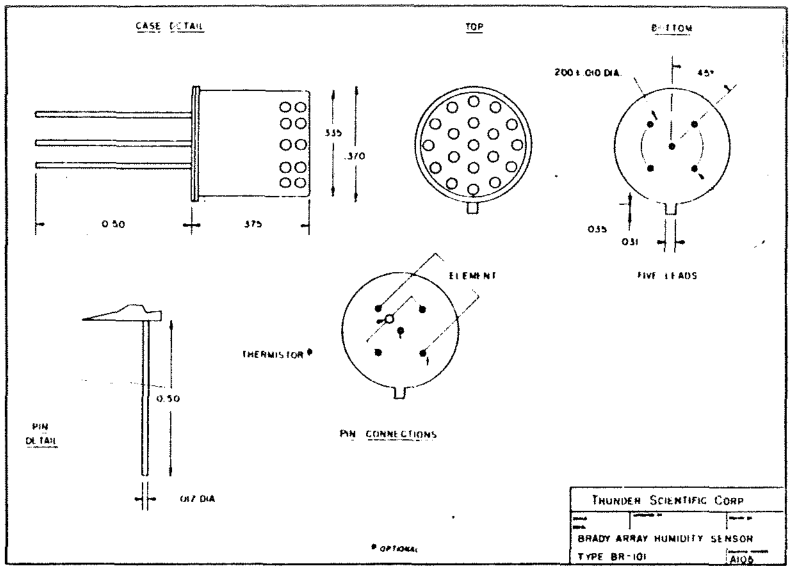
THUNDER SCIENTIFIC

BRADY ARRAY MODEL BR-101





THE BRADY ARRAY IS A NEW TYPE OF SOLID STATE SENSOR RECENTLY DEVELOPED BY THUNDER SCIENTIFIC, INTENDED FOR PRECISE MEASUREMENT, ANALYSIS, OR CONTROL OF VARIOUS HUMIDITY ENVIRONMENTS AND FOR USE IN TEXTILES, DRUGS, FOOD PACKAGING AND PROCESSING, GROWTH CHAMBERS, MEDICAL AND ANY OTHER FIELDS RELATED TO THE ENVIRONMENTAL SCIENCES WHERE IT IS DESIRED TO MEASURE, MAINTAIN AND CONTROL OPTIMUM HUMIDITY OR MOISTURE CONDITIONS.

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SPECIAL PRESSURE OR VACUUM FITTINGS AND ASSEMBLIES CAN BE SUPPLIED BY THUNDER SCIENTIFIC FOR SPECIALIZED ASSEMBLIES.

SPECIFICATIONS MODEL BR-101

ELECTRICAL:

HUMIDITY RANGE	<5% R.H. TO 100% R.H.
GUARANTEED ACCURACY	±4% R.H.*
TYPICAL ACCURACY	±2% R.H. OR BETTER
RESOLUTION	BETTER THAN 0.1% R.H.
TEMPERATURE RANGE	−20°C TO 70°C**
EXCITATION VOLTAGE CALIBRATION	UNLESS SPECIFIED CALIBRATED AGAINST A TYPICAL **LOAD OF 1 MEGOHM ±1% AT 5 VAC RMS SINE WAVE**

PHYSICAL:

ENCLOSURE	FIVE PIN OR EIGHT PIN TO-5 TYPE TRANSISTOR HEADER AND CAN, GOLD PLATED
SIZE	0.375" HIGH X 0.370 DIAM.
LEAD LENGTH	0.5" GOLD PLATED
WEIGHT	1.0 GRAM

* ALLOWING FOR POSSIBLE INHERENT INACCURACIES OF CUSTOMERS' END INSTRUMENTS AND INTERFACE.
**QUOTATION ON MILITARY TEMP. RANGE − 55°C TO +125°C AVAILABLE ON SPECIAL REQUEST.

Thunder Scientific Accepts No Responsibility for Inaccuracies Existing in any Interface or End Instrument Readout Other Than an Interface or Associated End Instrument Supplied for Use with the Brady Array by Thunder Scientific.

PRICE $100.00
QUANTITY PRICES AVAILABLE UPON REQUEST

PRICES AND SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

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TEL. (505) 265-8701

FIGURE 2

BR-101R

The "-R" option of the basic BR-101 Brady Array is a ruggedized, low profile mounting, on a TO-5 type transistor header.

BR-101-LT

The "-LT" option of the basic BR-101 Brady Array contains a special thermistor element which, when used with the "-LT" option on a standard TSC signal conditioner, provides a linearized analog signal for temperature readout. The standard temperature range is -30°C to 50°C. (Other ranges available on special request.)

NOTE: -R and -LT options may be combined if desired.

MM-101

The MM-101 mount provides protection against particle impact, water splash etc., for the BR-101R humidity sensor by placing an 8 micron, replaceable filter between the sensor and the outside environment. The MM-101 attaches directly on to a standard C-3A or C-3B environmentalized cable.

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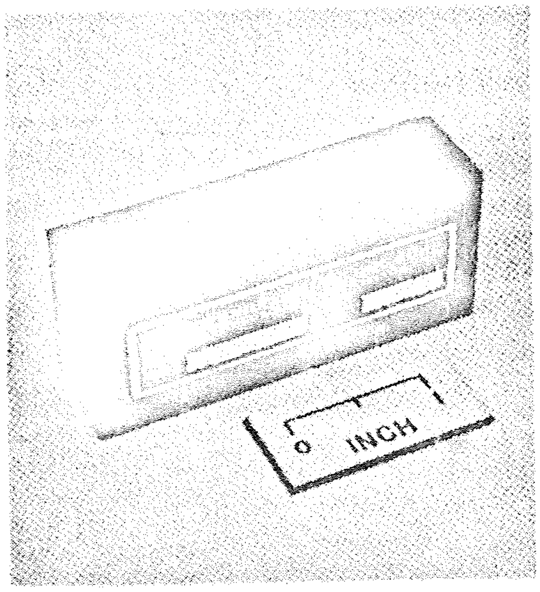
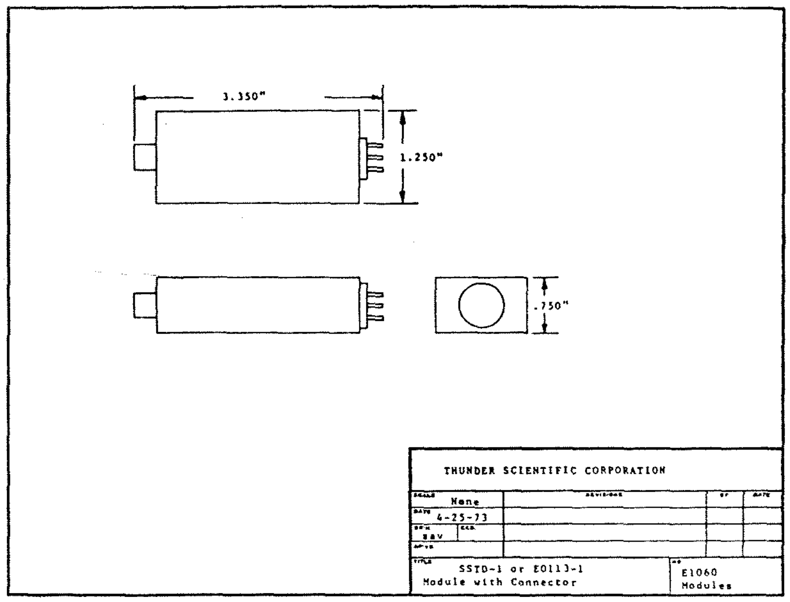
THUNDER SCIENTIFIC®

EXCITATION OSCILLATOR MODEL EO113-1





THE EO113-1 EXCITATION OSCILLATOR IS ONE OF A CONTINUING SERIES OF DEVICES DESIGNED BY THUNDER SCIENTIFIC TO PROVIDE SUPERIOR PERFORMANCE AND OPERATING FLEXIBILITY WITH BRADY ARRAY HUMIDITY SENSOR SYSTEMS, OR OTHER SIMILAR SYSTEMS REQUIREMENTS WHERE A SOURCE OF EXCITATION MAY BE REQUIRED.

HIGH RELIABILITY IS ACHIEVED WITH ALL SOLID-STATE POTTED CONSTRUCTION AND DENSE PACKAGING AFFORDING OPTIMUM CONSERVATION OF VOLUME WHERE SPACE IS AT A PREMIUM.

QUOTATIONS UPON EO113-1 MODULES IN FREQUENCY RANGES OTHER THAN SPECIFIED ARE AVAILABLE.

SPECIFICATION MODEL EO113-1

ELECTRICAL:

OUTPUT	5 VRMS SINE WAVE
FREQUENCY	1000 Hz
TEMPERATURE RANGE	$0^{o}C$ TO $75^{o}C$
POWER REQUIREMENT	15 VDC @ 3 m.a.
CONNECTOR	PIGTAIL OR P.C. PINS. SPECIFY.

PHYSICAL:

ENCLOSURE	POTTED MODULE
SIZE	1.25" x 2.80" x 0.750"
WEIGHT	60 GRAMS

SINGLE CHANNEL	\$100.00
MULTIPLE CHANNELS	200.00

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FIGURE 3

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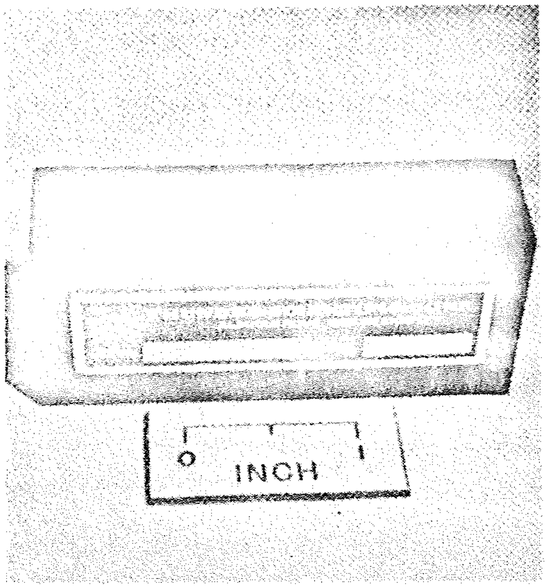
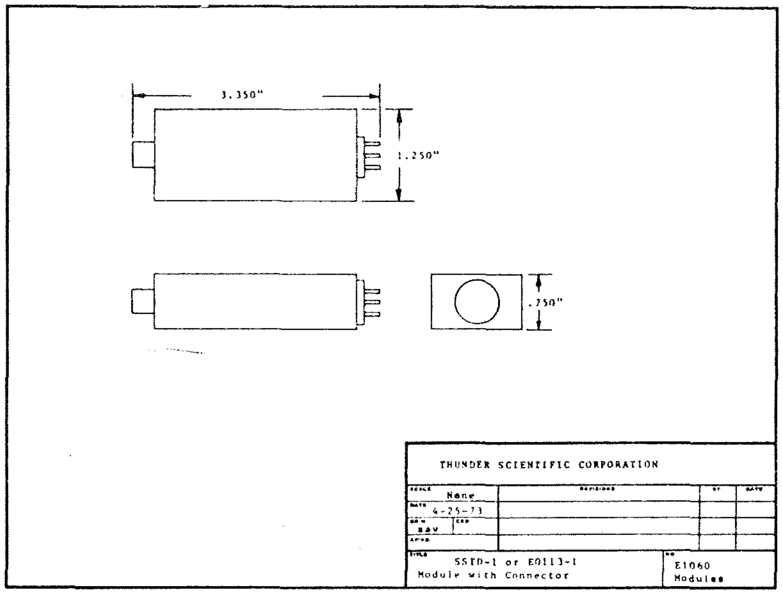
SYNCHRONIZED SATURATED TRANSISTOR DEMODULATOR MODEL SSTD-1





THE SSTD-1 IS ANOTHER PRECISION MODULE OFFERED BY THUNDER SCIENTIFIC CORPORATION SPECIFICALLY FOR USE WITH THE BRADY ARRAY HUMIDITY SENSOR. THE MODULAR CONSTRUCTION AND SOLID-STATE DESIGN OF THESE DEMODULATORS PROVIDE A HIGH DEGREE OF FLEXIBILITY AND RELIABILITY WITH SIGNIFICANT IMPROVEMENT EVIDENT OVER GERMANIUM AND SILICON DIODE DEMODULATORS.

UNIQUE TRANSISTORIZED CIRCUITRY VIRTUALLY ELIMINATES TEMPERATURE INSTABILITY AND VOLTAGE THRESHOLD PROBLEMS, RESULTING IN HIGHLY RELIABLE TRACKING OF AC INPUT TO DC OUTPUT SIGNALS.

IT SHOULD BE NOTED THAT A FLOATING OUTPUT IS PROVIDED, AS WELL AS A HIGH INPUT IMPEDANCE FOR MAXIMUM APPLICATION VERSATILITY.

SPECIAL ORDER MODIFICATIONS ARE ALSO AVAILABLE TO PROVIDE OTHER OUTPUT COMBINATIONS. FOR DETAILS, CONTACT THUNDER SCIENTIFIC.

SPECIFICATIONS MODEL SSTD-1

ELECTRICAL:

INPUT INPEDANCE	100 MEGOHMS
OUTPUT RESISTANCE	15,000 OHMS
LOAD RESISTANCE	1 MEGOHM OR GREATER
INPUT SIGNAL	0 TO 5 VRMS @ 1 KHz
OUTPUT SIGNAL	0 TO 5 VOLTS DC OR GREATER. ISOLATED, POSITIVE OR NEGATIVE DC.
TEMPERATURE RANGE	0°C TO 75°C
CONNECTOR	PIGTAIL OR P.C. PINS. SPECIFY.

PHYSICAL:

ENCLOSURE	POTTED MODULE
SIZE	1.25" x 2.80" x 0.750"
WEIGHT	60 GRAMS

PRICES AND SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE.

PRICE: $100.00
QUANTITY PRICES AVAILABLE UPON REQUEST

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FIGURE 4